(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 368 919 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
15.05.2024 Bulletin 2024/20

(21) Application number: **21949289.9**

(22) Date of filing: **07.07.2021**

(51) International Patent Classification (IPC):
F25B 39/04 *(2006.01)* ***F28F 9/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F28D 1/05391; F25B 39/04; F28F 9/02;
F28F 1/022; F28F 1/126; F28F 1/32; F28F 2215/00;
F28F 2270/00

(86) International application number:
PCT/JP2021/025605

(87) International publication number:
WO 2023/281655 (12.01.2023 Gazette 2023/02)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

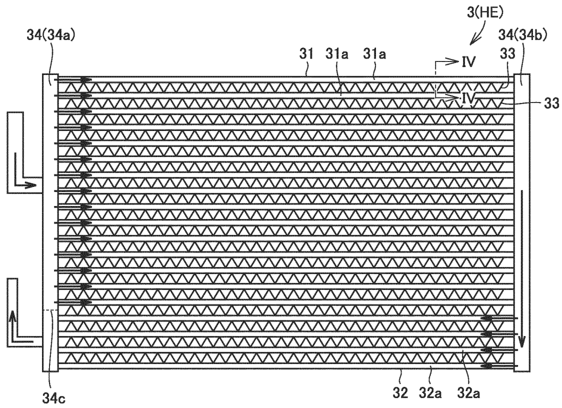
(72) Inventors:
- **MATSUDA, Takuya**
  Tokyo 100-8310 (JP)
- **ISHIBASHI, Akira**
  Tokyo 100-8310 (JP)

(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
Theresienhöhe 11a
80339 München (DE)

(54) HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE

(57) A heat exchanger (HE) includes: a first heat transfer portion (31a) having a plurality of first heat transfer tubes (31); a second heat transfer portion (32a) having a plurality of second heat transfer tubes (32); and a zeotropic refrigerant flowing through the plurality of first heat transfer tubes (31a) of the first heat transfer portion (31) and the plurality of second heat transfer tubes (32a) of the second heat transfer portion (32). The plurality of first heat transfer tubes (31a) of the first heat transfer portion (31) and the plurality of second heat transfer tubes (32a) of the second heat transfer portion (32) are arranged in a line. The first heat transfer portion (31) and the second heat transfer portion (32) are configured to allow the zeotropic refrigerant to flow from the first heat transfer portion (31) and turn only once into the second heat transfer portion (32).

FIG.3



EP 4 368 919 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat exchanger and a refrigeration cycle apparatus.

BACKGROUND ART

[0002] Arranging heat transfer tubes in multiple lines has been proposed in order to enhance the performance of a heat exchanger of a refrigeration cycle apparatus. Since a heat exchanger is mounted in a limited space, arranging heat transfer tubes in multiple lines can lead to an increase in mounting density of the heat transfer tubes and an increase in heat transfer area. For example, a heat exchanger of an indoor unit of an air conditioning apparatus described in Japanese Patent Laying-Open No. 2014-40983 (PTL 1) has heat transfer tubes arranged in multiple lines.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2014-40983

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In the case where a zeotropic refrigerant is used in a heat exchanger having heat transfer tubes arranged in multiple lines, temperature distribution occurs in the zeotropic refrigerant, and due to this, a heat exchange loss occurs when the refrigerant flows parallel to an air flow. In addition, in the case where a zeotropic refrigerant is used when a heat exchanger having heat transfer tubes arranged in multiple lines is applied to an outdoor heat exchanger and functions as an evaporator, temperature distribution occurs in the zeotropic refrigerant, and due to this, the temperature on the windward side decreases and frost is likely to form when the refrigerant flows parallel to an air flow.

[0005] The present disclosure has been made in light of the above-described problem, and an object thereof is to provide a heat exchanger and a refrigeration cycle apparatus that make it possible to suppress a heat exchange loss while using a zeotropic refrigerant, and to suppress frost formation.

SOLUTION TO PROBLEM

[0006] A heat exchanger of the present disclosure includes: a first heat transfer portion having a plurality of first heat transfer tubes; a second heat transfer portion having a plurality of second heat transfer tubes; and a zeotropic refrigerant flowing through the plurality of first heat transfer tubes of the first heat transfer portion and the plurality of second heat transfer tubes of the second heat transfer portion. The plurality of first heat transfer tubes of the first heat transfer portion and the plurality of second heat transfer tubes of the second heat transfer portion are arranged in a line. The first heat transfer portion and the second heat transfer portion are configured to allow the zeotropic refrigerant to flow from the first heat transfer portion and turn only once into the second heat transfer portion.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the heat exchanger of the present disclosure, it is possible to suppress a heat exchange loss while using a zeotropic refrigerant, and to suppress frost formation.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a refrigerant circuit diagram of a refrigeration cycle apparatus according to a first embodiment.
Fig. 2 is a top view schematically showing an internal structure of an outdoor unit of the refrigeration cycle apparatus according to the first embodiment.
Fig. 3 is a front view schematically showing a heat exchanger according to the first embodiment.
Fig. 4 is a cross-sectional view schematically showing a first heat transfer tube and a second heat transfer tube of the heat exchanger according to the first embodiment.
Fig. 5 is a cross-sectional view schematically showing a first modification of the heat exchanger according to the first embodiment.
Fig. 6 is a cross-sectional view schematically showing a second modification of the heat exchanger according to the first embodiment.
Fig. 7 is a front view schematically showing a third modification of the heat exchanger according to the first embodiment.
Fig. 8 is a front view schematically showing a fourth modification of the heat exchanger according to the first embodiment.
Fig. 9 is a front view schematically showing a fifth modification of the heat exchanger according to the first embodiment.
Fig. 10 is a front view schematically showing a heat exchanger according to a second embodiment.
Fig. 11 is a perspective view schematically showing a fin in a first modification of the heat exchanger according to the second embodiment.
Fig. 12 is a front view schematically showing a second modification of the heat exchanger according to the second embodiment.

DESCRIPTION OF EMBODIMENTS

[0009] Embodiments will be described hereinafter with reference to the drawings, in which the same or corresponding portions are denoted by the same reference characters and description thereof will not be repeated.

First Embodiment

[0010] A configuration of a refrigeration cycle apparatus 100 according to a first embodiment will be described with reference to Fig. 1. In the first embodiment, an air conditioner is described as an example of refrigeration cycle apparatus 100. A solid arrow in Fig. 1 indicates a flow of refrigerant during cooling operation. A dashed arrow in Fig. 1 indicates a flow of refrigerant during heating operation.

[0011] As shown in Fig. 1, refrigeration cycle apparatus 100 includes a compressor 1, a four-way valve 2, an outdoor heat exchanger 3, an expansion valve 4, an indoor heat exchanger 5, an outdoor blower 6, an indoor blower 7, and a controller 8. A heat exchanger HE according to the first embodiment is applied to outdoor heat exchanger 3. Refrigeration cycle apparatus 100 includes an outdoor unit 101, and an indoor unit 102 connected to outdoor unit 101.

[0012] A refrigerant circuit 10 includes compressor 1, four-way valve 2, outdoor heat exchanger 3, expansion valve 4, and indoor heat exchanger 5. Compressor 1, four-way valve 2, outdoor heat exchanger 3, expansion valve 4, and indoor heat exchanger 5 are connected by a pipe 20. Refrigerant circuit 10 is configured to circulate the refrigerant.

[0013] The refrigerant is a zeotropic refrigerant. The zeotropic refrigerant includes R32, and may include R1234yf as another refrigerant. The zeotropic refrigerant may include R1123 or R1234ze as another refrigerant. Alternatively, the zeotropic refrigerant may be a mixture of three or more types of refrigerant.

[0014] Compressor 1, four-way valve 2, outdoor heat exchanger 3, expansion valve 4, outdoor blower 6, and controller 8 are housed in outdoor unit 101. Indoor heat exchanger 5 and indoor blower 7 are housed in indoor unit 102. Outdoor unit 101 and indoor unit 102 are connected by a gas pipe 21 and a liquid pipe 22. A part of pipe 20 forms gas pipe 21 and liquid pipe 22.

[0015] Refrigerant circuit 10 is configured such that the refrigerant circulates in the order of compressor 1, four-way valve 2, outdoor heat exchanger 3, expansion valve 4, indoor heat exchanger 5, and four-way valve 2 during the cooling operation. In addition, refrigerant circuit 10 is configured such that the refrigerant circulates in the order of compressor 1, four-way valve 2, indoor heat exchanger 5, expansion valve 4, outdoor heat exchanger 3, and four-way valve 2 during the heating operation.

[0016] Compressor 1 is configured to compress the refrigerant. Compressor 1 is for compressing the zeotropic refrigerant flowing into heat exchanger HE. Compressor 1 is configured to compress and discharge the suctioned refrigerant. Compressor 1 may be configured to be capacity-variable. Compressor 1 may be configured such that a capacity thereof varies through the adjustment of the rotation speed of compressor 1 based on an instruction from controller 8.

[0017] Four-way valve 2 is configured to switch the flow of the refrigerant to allow the refrigerant compressed by compressor 1 to flow to outdoor heat exchanger 3 or indoor heat exchanger 5. Four-way valve 2 has a first port P1 to a fourth port P4. First port P1 is connected to the discharge side of compressor 1. Second port P2 is connected to the suction side of compressor 1. Third port P3 is connected to outdoor heat exchanger 3. Fourth port P4 is connected to indoor heat exchanger 5. Four-way valve 2 is configured to allow the refrigerant discharged from compressor 1 to flow to outdoor heat exchanger 3 during the cooling operation. During the cooling operation, third port P3 is connected to first port P1 and fourth port P4 is connected to second port P2 in four-way valve 2. In addition, four-way valve 2 is configured to allow the refrigerant discharged from compressor 1 to flow to indoor heat exchanger 5 during the heating operation. During the heating operation, fourth port P4 is connected to first port P1 and third port P3 is connected to second port P2 in four-way valve 2.

[0018] Outdoor heat exchanger 3 is configured to perform heat exchange between the refrigerant flowing inside outdoor heat exchanger 3 and the air flowing outside outdoor heat exchanger 3. Outdoor heat exchanger 3 is configured to function as a condenser that condenses the refrigerant during the cooling operation, and to function as an evaporator that evaporates the refrigerant during the heating operation.

[0019] Expansion valve 4 is configured to expand the refrigerant condensed by the condenser to decompress the refrigerant. Expansion valve 4 is configured to decompress the refrigerant condensed by outdoor heat exchanger 3 during the cooling operation, and to decompress the refrigerant condensed by indoor heat exchanger 5 during the heating operation. Expansion valve 4 is, for example, a solenoid expansion valve.

[0020] Indoor heat exchanger 5 is configured to perform heat exchange between the refrigerant flowing inside indoor heat exchanger 5 and the air flowing outside indoor heat exchanger 5. Indoor heat exchanger 5 is configured to function as an evaporator that evaporates the refrigerant during the cooling operation, and to function as a condenser that condenses the refrigerant during the heating operation.

[0021] Outdoor blower 6 is configured to blow the outdoor air to outdoor heat exchanger 3. That is, outdoor blower 6 is configured to supply the air to outdoor heat exchanger 3.

[0022] Indoor blower 7 is configured to blow the indoor air to indoor heat exchanger 5. That is, indoor blower 7 is configured to supply the air to indoor heat exchanger 5.

[0023] Controller 8 is configured to control the devices of refrigeration cycle apparatus 100 by, for example, performing calculations or providing instructions. Controller 8 is electrically connected to compressor 1, four-way valve 2, expansion valve 4, outdoor blower 6, indoor blower 7 and the like to control the operation of these components.

[0024] A configuration of outdoor unit 101 will be described in detail with reference to Fig. 2.

[0025] Outdoor unit 101 has compressor 1, four-way valve 2, outdoor heat exchanger 3, expansion valve 4, outdoor blower 6, and controller 8. Outdoor unit 101 has a housing 101a and a separator 101b. The interior of housing 101a is partitioned into a machine chamber 101c and a blower chamber 101d by separator 101b. Compressor 1, four-way valve 2, expansion valve 4, and controller 8 are arranged in machine chamber 101c. Outdoor heat exchanger 3 and outdoor blower 6 are arranged in blower chamber 101d.

[0026] Outdoor heat exchanger 3 is arranged to face outdoor blower 6. Outdoor heat exchanger 3 is arranged along a rear surface of housing 101a. Outdoor heat exchanger 3 extends in a width direction of housing 101a. Outdoor heat exchanger 3 is formed in a line.

[0027] A configuration of outdoor heat exchanger 3 to which heat exchanger HE according to the first embodiment is applied will be described in detail with reference to Figs. 3 and 4. A solid arrow in Fig. 3 indicates a flow of the refrigerant during the cooling operation.

[0028] In the present embodiment, outdoor heat exchanger 3 includes a first heat transfer portion 31, a second heat transfer portion 32, a plurality of fins 33, a header 34, and the zeotropic refrigerant. Outdoor heat exchanger 3 is a parallel flow-type heat exchanger. In the present embodiment, first heat transfer portion 31 is arranged on the upper side of second heat transfer portion 32. That is, first heat transfer portion 31 forms an upper section, and second heat transfer portion 32 forms a lower section.

[0029] First heat transfer portion 31 has a plurality of first heat transfer tubes 31a. The plurality of first heat transfer tubes 31a of first heat transfer portion 31 are configured to extend linearly. Second heat transfer portion 32 has a plurality of second heat transfer tubes 32a. The plurality of second heat transfer tubes 32a of second heat transfer portion 32 are configured to extend linearly. The plurality of first heat transfer tubes 31a of first heat transfer portion 31 and the plurality of second heat transfer tubes 32a of second heat transfer portion 32 are arranged in a line. The plurality of first heat transfer tubes 31a are overlaid on each other. The plurality of second heat transfer tubes 32a are overlaid on each other. The plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a are overlaid on each other.

[0030] Each of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 and the plurality of second heat transfer tubes 32a of second heat transfer portion 32 is at least any one of an oval tube, a circular tube and a flat perforated tube. In the present embodiment, each of the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a is a flat tube. The flat tube has a shorter axis in a direction in which the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a are aligned in a line, and a longer axis in a direction orthogonal to the direction in which the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a are aligned in a line. Each of the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a has one refrigerant flow path RP.

[0031] The zeotropic refrigerant flows through the plurality of first heat transfer tubes 31a of first heat transfer portion 31 and the plurality of second heat transfer tubes 32a of second heat transfer portion 32. First heat transfer portion 31 and second heat transfer portion 32 are configured to allow the zeotropic refrigerant to flow from first heat transfer portion 31 and turn only once into second heat transfer portion 32.

[0032] The number of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 is smaller than the number of the plurality of second heat transfer tubes 32a of second heat transfer portion 32. A ratio of the number of the plurality of second heat transfer tubes 32a of second heat transfer portion 32 to the number of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 is equal to or lower than 30%. When an azeotropic refrigerant is used, the ratio of the number of the plurality of second heat transfer tubes 32a of second heat transfer portion 32 to the number of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 is 35%. The ratio of the number of the plurality of second heat transfer tubes 32a of second heat transfer portion 32 to the number of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 is lower than that when the azeotropic refrigerant is used.

[0033] In the present embodiment, each of the plurality of fins 33 is a corrugated fin. Each of the plurality of fins 33 is arranged between first heat transfer tubes 31a adjacent to each other, of the plurality of first heat transfer tubes 31a. Each of the plurality of fins 33 is in contact with each of first heat transfer tubes 31a adjacent to each other, of the plurality of first heat transfer tubes 31a. Each of the plurality of fins 33 is arranged between second heat transfer tubes 32a adjacent to each other, of the plurality of second heat transfer tubes 32a. Each of the plurality of fins 33 is in contact with each of second heat transfer tubes 32a adjacent to each other, of the plurality of second heat transfer tubes 32a.

[0034] Header 34 is connected to each of both ends of each of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 and the plurality of second heat transfer tubes 32a of second heat transfer portion 32. Header 34 includes a first header portion 34a and a second header portion 34b. First header portion 34a is connected to one end (first end) of each of the plurality of first heat transfer tubes 31a of first heat transfer portion

31 and the plurality of second heat transfer tubes 32a of second heat transfer portion 32. Second header portion 34b is connected to the other end (second end) of each of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 and the plurality of second heat transfer tubes 32a of second heat transfer portion 32.

[0035] First header portion 34a has a refrigerant inlet and a refrigerant outlet. A partition portion 34c is provided in first header portion 34a. Partition portion 34c is arranged at a boundary between first heat transfer portion 31 and second heat transfer portion 32. Therefore, the refrigerant flowing from the refrigerant inlet into first header portion 34a flows through the plurality of first heat transfer tubes 3 1a of first heat transfer portion 31 to second header portion 34b, turns in second header portion 34b, and flows through the plurality of second heat transfer tubes 32a to first header portion 34a. The refrigerant flowing to first header portion 34a flows out through the refrigerant outlet. In this way, the refrigerant flows from first heat transfer portion 31 and turns only once into second heat transfer portion 32.

[0036] Next, the operation of refrigeration cycle apparatus 100 according to the first embodiment will be described with reference to Figs. 1 to 3.

[0037] Refrigeration cycle apparatus 100 can selectively perform the cooling operation and the heating operation. During the cooling operation, the refrigerant circulates in refrigerant circuit 10 in the order of compressor 1, four-way valve 2, outdoor heat exchanger 3, expansion valve 4, indoor heat exchanger 5, and four-way valve 2. During the cooling operation, outdoor heat exchanger 3 functions as a condenser. Heat exchange is performed between the refrigerant flowing through outdoor heat exchanger 3 and the air blown by outdoor blower 6. During the cooling operation, indoor heat exchanger 5 functions as an evaporator. Heat exchange is performed between the refrigerant flowing through indoor heat exchanger 5 and the air blown by indoor blower 7.

[0038] The high-pressure gas refrigerant discharged from compressor 1 flows into the refrigerant inlet of first header portion 34a of outdoor heat exchanger 3 via a gas inflow pipe. The high-pressure gas refrigerant flowing into first header portion 34a is distributed into the plurality of first heat transfer tubes 31a of first heat transfer portion 31 and condenses to a degree of dryness of approximately 0.1 to thereby change into gas-liquid two-phase refrigerant. The gas-liquid two-phase refrigerant joins in second header portion 34b, is distributed into the plurality of second heat transfer tubes 32a of second heat transfer portion 32, and changes into supercooled liquid refrigerant beyond a saturated liquid. The supercooled liquid refrigerant joins in first header portion 34a and flows out through the refrigerant outlet of first header portion 34a.

[0039] During the heating operation, the refrigerant circulates in refrigerant circuit 10 in the order of compressor 1, four-way valve 2, indoor heat exchanger 5, expansion valve 4, outdoor heat exchanger 3, and four-way valve 2. During the heating operation, indoor heat exchanger 5 functions as a condenser. Heat exchange is performed between the refrigerant flowing through indoor heat exchanger 5 and the air blown by indoor blower 7. During the heating operation, outdoor heat exchanger 3 functions as an evaporator. Heat exchange is performed between the refrigerant flowing through outdoor heat exchanger 3 and the air blown by outdoor blower 6.

[0040] The supercooled liquid refrigerant flowing from indoor heat exchanger 5 into expansion valve 4 is decompressed in expansion valve 4 to thereby change into low-pressure gas-liquid two-phase refrigerant having a low degree of dryness. The low-pressure gas-liquid two-phase refrigerant flows into the refrigerant inlet of first header portion 34a of outdoor heat exchanger 3. The low-pressure gas-liquid two-phase refrigerant flowing into first header portion 34a is distributed into the plurality of second heat transfer tubes 32a of second heat transfer portion 32 and evaporates. The low-pressure gas-liquid two-phase refrigerant joins in second header portion 34b, is distributed into the plurality of first heat transfer tubes 31a of first heat transfer portion 31, and further evaporates and vaporizes into superheated vapor refrigerant. The superheated vapor refrigerant joins in first header portion 34a and flows out through the refrigerant outlet of first header portion 34a.

[0041] Refrigeration cycle apparatus 100 may be able to selectively perform defrosting operation. During the defrosting operation, the refrigerant circulates in refrigerant circuit 10 similarly to during the cooling operation. During the defrosting operation, outdoor heat exchanger 3 functions as a condenser and indoor heat exchanger 5 functions as an evaporator.

[0042] Next, modifications of outdoor heat exchanger 3 to which heat exchanger HE according to the first embodiment is applied will be described.

[0043] Referring to Fig. 5, in a first modification of outdoor heat exchanger 3 according to the first embodiment, each of the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a is a circular tube.

[0044] Referring to Fig. 6, in a second modification of outdoor heat exchanger 3 according to the first embodiment, each of the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a is a flat perforated tube. The flat perforated tube has a plurality of refrigerant flow paths RP. The plurality of refrigerant flow paths RP are arranged as being aligned in a longer axis direction of the flat perforated tube.

[0045] Referring to Fig. 7, in a third modification of outdoor heat exchanger 3 according to the first embodiment, outdoor heat exchanger 3 has the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a, header 34, and a plurality of plate fins 35. Each of the plurality of plate fins 35 is formed into a thin plate. The plurality of plate fins 35 are arranged to be stacked on top of each other. Each of the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a passes through the plurality of plate fins 35. Outdoor heat exchanger 3 is a fin-and-tube-type heat exchanger.

[0046] Referring to Fig. 8, in a fourth modification of outdoor heat exchanger 3 according to the first embodiment, outdoor heat exchanger 3 has the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a, and header 34. In the fourth modification, outdoor heat exchanger 3 does not have a fin.

[0047] Referring to Fig. 9, in a fifth modification of outdoor heat exchanger 3 according to the first embodiment, outdoor heat exchanger 3 has the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a, the plurality of fins 33, and header 34.

[0048] Each of the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a extends in a vertical direction (gravity direction). Therefore, the water discharge performance of each of the plurality of first heat transfer tubes 31a and the plurality of second heat transfer tubes 32a is enhanced. Each of the plurality of fins 33 is a corrugated fin. The corrugated fin extends in the vertical direction (gravity direction). Therefore, the water discharge performance of the corrugated fin is enhanced. Header 34 extends in a horizontal direction. Therefore, uniform distribution of the refrigerant in header 34 is enhanced.

[0049] Next, the function and effect of the present embodiment will be described.

[0050] In heat exchanger HE according to the present embodiment, the plurality of first heat transfer tubes 31a of first heat transfer portion 31 and the plurality of second heat transfer tubes 32a of second heat transfer portion 32 are arranged in a line. Therefore, the zeotropic refrigerant does not flow parallel to the air flow. Thus, a heat exchange loss caused by a temperature gradient of the zeotropic refrigerant can be suppressed. That is, a heat exchange loss caused by a decrease in temperature difference between the zeotropic refrigerant and the air due to a temperature gradient of the zeotropic refrigerant can be suppressed. As a result, the heat exchange efficiency can be increased. Furthermore, since the zeotropic refrigerant does not flow parallel to the air flow, a decrease in temperature on the windward side when heat exchanger HE is applied to outdoor heat exchanger 3 and functions as an evaporator can be suppressed. Therefore, frost formation can be suppressed.

[0051] In addition, first heat transfer portion 31 and second heat transfer portion 32 are configured to allow the zeotropic refrigerant to flow from first heat transfer portion 31 and turn only once into second heat transfer portion 32. Therefore, a heat exchange loss between the refrigerant caused by a temperature difference in the gas-liquid two-phase region of the zeotropic refrigerant can be minimized. That is, a heat exchange loss between the refrigerant that occurs at every turn due to a temperature gradient in the gas-liquid two-phase region of the zeotropic refrigerant can be minimized. As a result, the heat exchange efficiency can be increased.

[0052] As described above, it is possible to suppress a heat exchange loss while using the zeotropic refrigerant in heat exchanger HE. In addition, it is possible to suppress frost formation while using the zeotropic refrigerant, when heat exchanger HE is applied to outdoor heat exchanger 3 and functions as an evaporator.

[0053] In heat exchanger HE according to the present embodiment, the ratio of the number of the plurality of second heat transfer tubes 32a of second heat transfer portion 32 to the number of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 is lower than that when the azeotropic refrigerant is used. Therefore, the number of the heat transfer tubes in the subcool portion of the zeotropic refrigerant can be made smaller than the number of the heat transfer tubes in the subcool portion when the azeotropic refrigerant is used. As a result, the heat exchange efficiency can be increased.

[0054] When heat exchanger HE functions as a condenser during the cooling operation, the saturated liquid temperature becomes lower than that when the azeotropic refrigerant is used, due to a temperature gradient of the zeotropic refrigerant, and thus, a limit degree of supercooling decreases inevitably. Therefore, the heat exchange efficiency can be increased by decreasing the number of second heat transfer tubes 32a of second heat transfer portion 32 where the zeotropic refrigerant changes into the supercooled liquid and increasing the number of first heat transfer tubes 31a of first heat transfer portion 31 where the gas-liquid two-phase refrigerant is condensed, as compared with when the azeortropic refrigerant is used.

[0055] Since the number of second heat transfer tubes 32a of second heat transfer portion 32 that is the lower section is smaller than the number of first heat transfer tubes 31a of first heat transfer portion 31 that is the upper section during the heating operation, the refrigerant temperature can be increased by increasing a pressure loss for first heat transfer portion 31 that is the upper section. As a result, icing in a lowermost part of second heat transfer portion 32 that is the lower section where root ice is likely to occur can be suppressed.

[0056] In heat exchanger HE according to the present embodiment, header 34 is connected to each of both ends of each of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 and the plurality of second heat transfer tubes 32a of second heat transfer portion 32. Therefore, heat exchanger HE can be a parallel flow-type heat exchanger.

[0057] In heat exchanger HE according to the present embodiment, each of the plurality of first heat transfer tubes 31a of first heat transfer portion 31 and the plurality of second heat transfer tubes 32a of second heat transfer portion 32 is at least any one of an oval tube, a circular tube and a flat perforated tube. Therefore, a degree of freedom in production can be increased.

[0058] Refrigeration cycle apparatus 100 according to the present embodiment includes above-described heat exchanger HE. Therefore, there can be provided refrigeration cycle apparatus 100 including heat exchanger

HE that makes it possible to suppress a heat exchange loss while using the zeotropic refrigerant, and to suppress frost formation.

Second Embodiment

[0059] Heat exchanger HE according to a second embodiment has the same configuration, operation, and function and effect as those of heat exchanger HE according to the first embodiment, unless otherwise specified.

[0060] Referring to Fig. 10, heat exchanger HE according to the second embodiment includes a heat blocking mechanism 40. Heat blocking mechanism 40 is provided between first heat transfer portion 31 and second heat transfer portion 32. Specifically, heat blocking mechanism 40 is provided between first heat transfer tubes 31a of first heat transfer portion 31 and second heat transfer tubes 32a of second heat transfer portion 32. Heat blocking mechanism 40 is a partition plate 41. Partition plate 41 is configured to be able to block heat transfer from first heat transfer tubes 31a to second heat transfer tubes 32a. Partition plate 41 has a thermal conductivity lower than that of fins 33.

[0061] Referring to Fig. 11, in each of fins 33 in a first modification of heat exchanger HE according to the second embodiment, heat blocking mechanism 40 is a slit 42. Slit 42 is provided to separate fin 33 midway between a peak portion and a valley portion of fin 33. The peak portion of fin 33 is fixed to first heat transfer tube 31a of first heat transfer portion 31, and the valley portion of fin 33 is fixed to second heat transfer tube 32a of second heat transfer portion 32.

[0062] Referring to Fig. 12, in a second modification of heat exchanger HE according to the second embodiment, heat blocking mechanism 40 is a gap 43. Fin 33 is not arranged in gap 43.

[0063] In heat exchanger HE according to the present embodiment, heat blocking mechanism 40 is provided between first heat transfer portion 31 and second heat transfer portion 32. Therefore, heat transfer between first heat transfer portion 31 and second heat transfer portion 32 can be suppressed by heat blocking mechanism 40. Thus, a heat exchange loss between the refrigerant that occurs at the turn between first heat transfer portion 31 and second heat transfer portion 32 due to a temperature gradient in the gas-liquid two-phase region of the zeotropic refrigerant can be suppressed.

[0064] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present disclosure is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0065] 1 compressor; 2 four-way valve; 3 outdoor heat exchanger; 4 expansion valve; 5 indoor heat exchanger; 6 outdoor blower; 7 indoor blower; 8 controller; 10 refrigerant circuit; 31 first heat transfer portion; 31a first heat transfer tube; 32 second heat transfer portion; 32a second heat transfer tube; 33 fin; 34 header; 34a first header portion; 34b second header portion; 40 heat blocking mechanism; 100 refrigeration cycle apparatus; HE heat exchanger.

Claims

1. A heat exchanger comprising:

a first heat transfer portion having a plurality of first heat transfer tubes;
a second heat transfer portion having a plurality of second heat transfer tubes; and
a zeotropic refrigerant flowing through the plurality of first heat transfer tubes of the first heat transfer portion and the plurality of second heat transfer tubes of the second heat transfer portion,
the plurality of first heat transfer tubes of the first heat transfer portion and the plurality of second heat transfer tubes of the second heat transfer portion being arranged in a line, and
the first heat transfer portion and the second heat transfer portion being configured to allow the zeotropic refrigerant to flow from the first heat transfer portion and turn only once into the second heat transfer portion.

2. The heat exchanger according to claim 1, wherein a ratio of the number of the plurality of second heat transfer tubes of the second heat transfer portion to the number of the plurality of first heat transfer tubes of the first heat transfer portion is lower than that when an azeotropic refrigerant is used.

3. The heat exchanger according to claim 1 or 2, further comprising a header, wherein
the header is connected to each of both ends of each of the plurality of first heat transfer tubes of the first heat transfer portion and the plurality of second heat transfer tubes of the second heat transfer portion.

4. The heat exchanger according to any one of claims 1 to 3, wherein
each of the plurality of first heat transfer tubes of the first heat transfer portion and the plurality of second heat transfer tubes of the second heat transfer portion is at least any one of an oval tube, a circular tube and a flat perforated tube.

5. The heat exchanger according to any one of claims 1 to 4, further comprising a heat blocking mechanism, wherein
the heat blocking mechanism is provided between the first heat transfer portion and the second heat transfer portion.

6. A refrigeration cycle apparatus comprising:

the heat exchanger as recited in any one of claims 1 to 5; and
a compressor configured to compress the zeotropic refrigerant flowing into the heat exchanger.

FIG.1

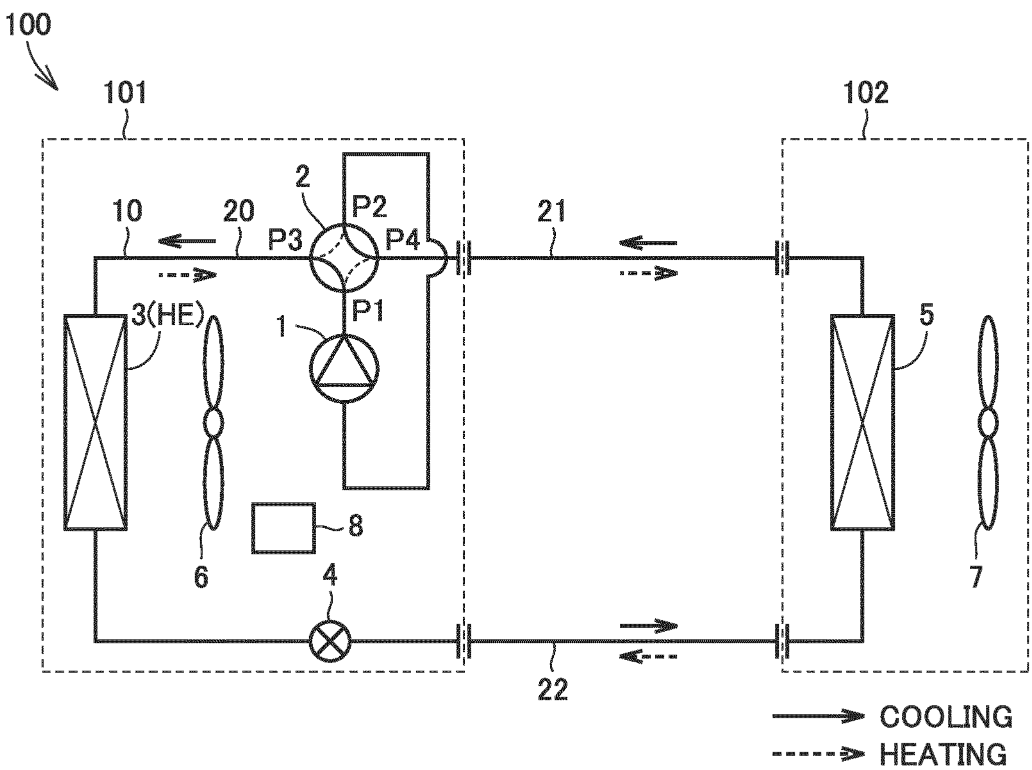


FIG.2

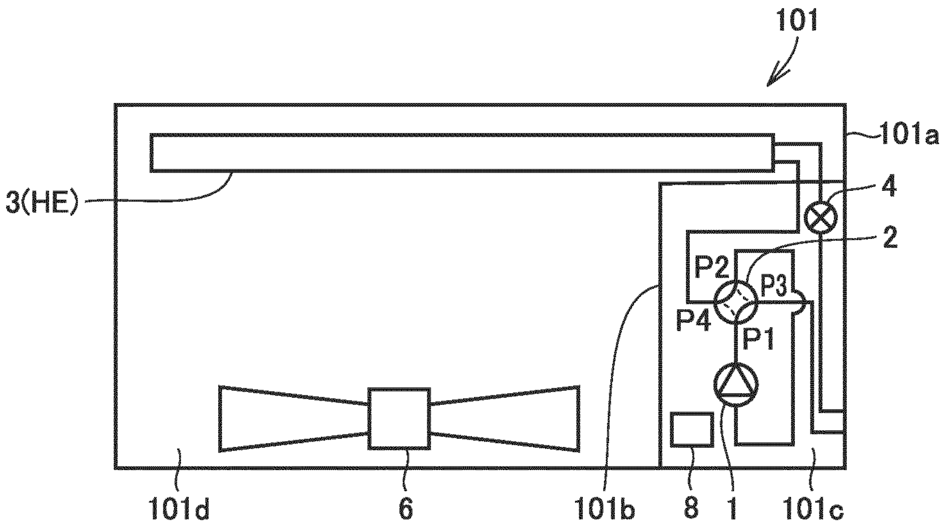


FIG.3

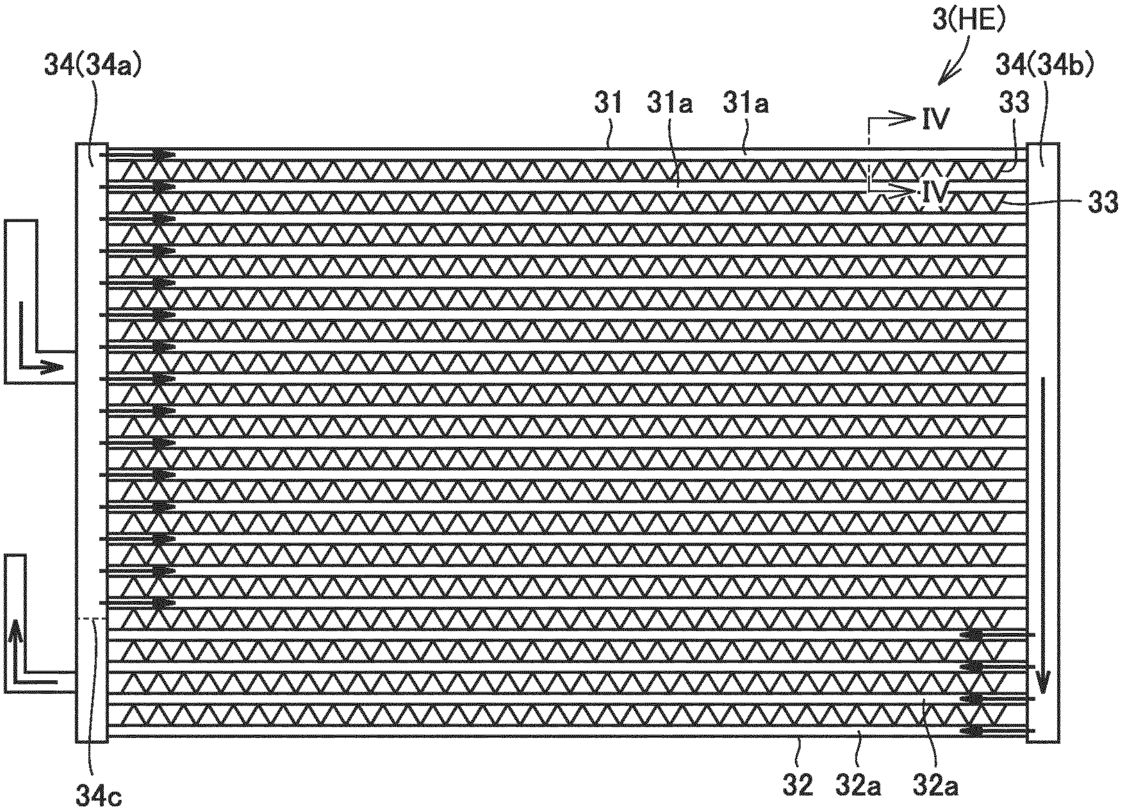


FIG.4

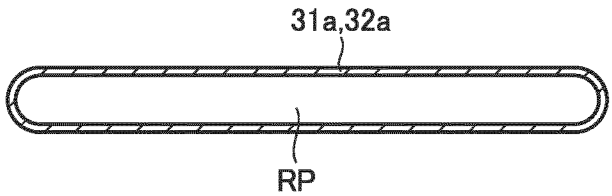


FIG.5

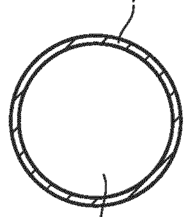


FIG.6

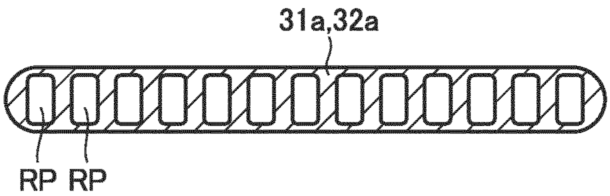


FIG.7

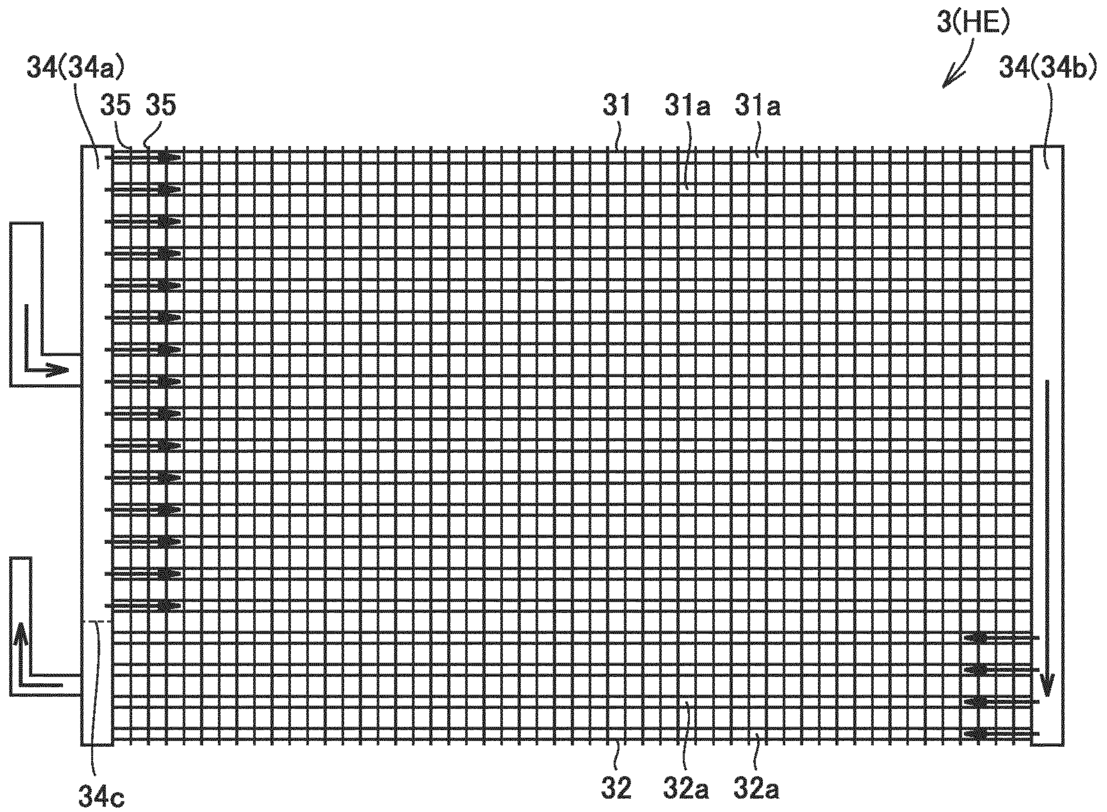


FIG.8

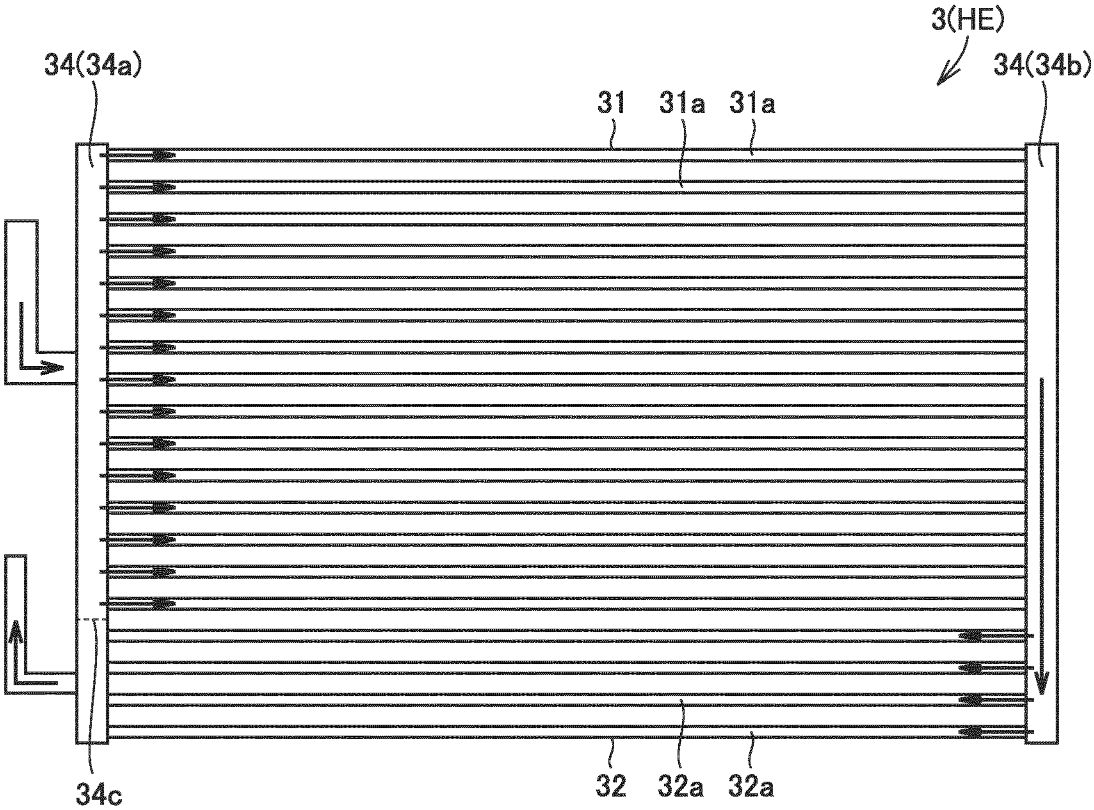


FIG.9

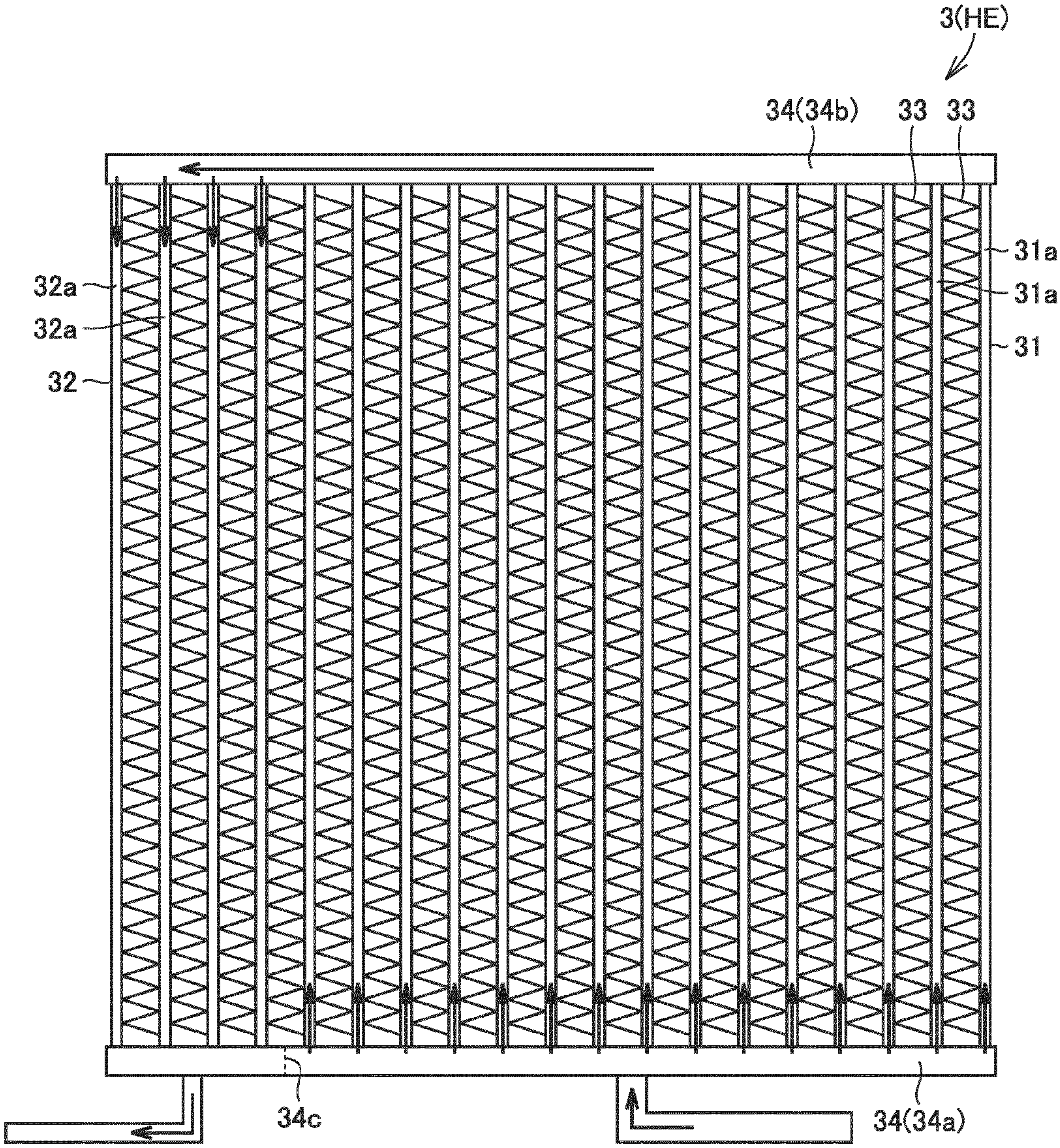


FIG.10

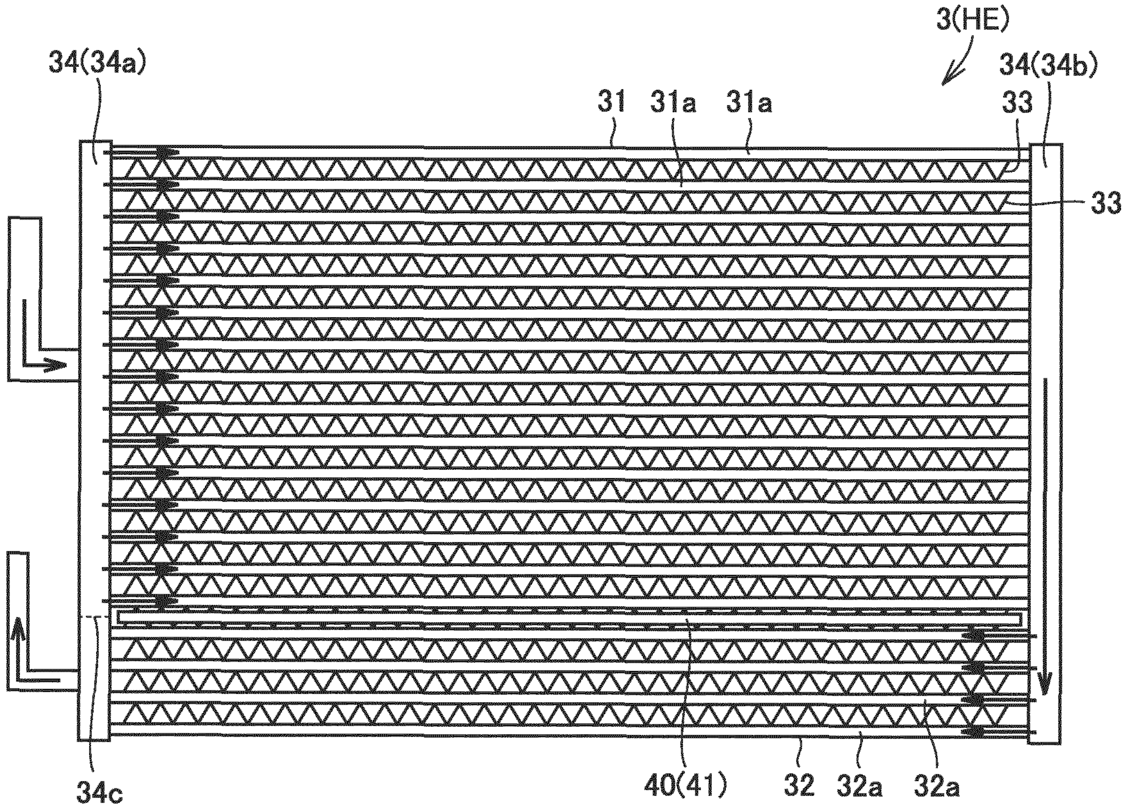


FIG.11

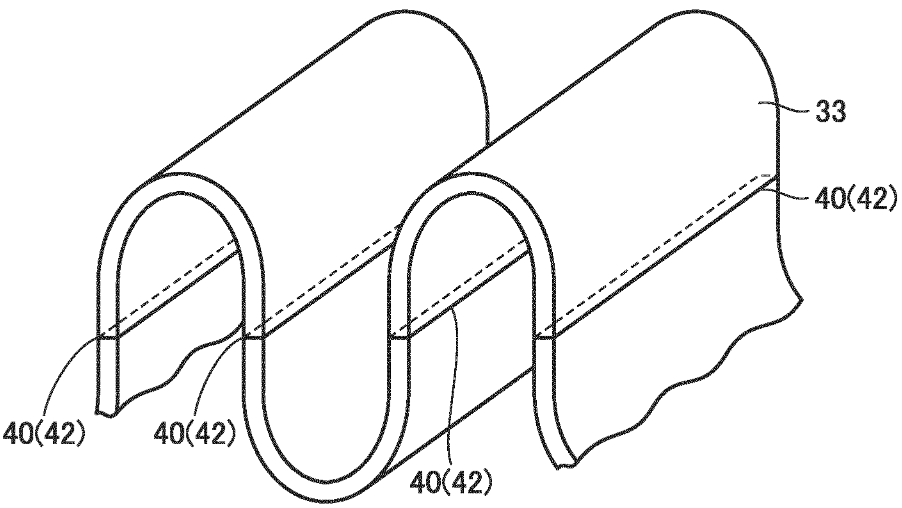
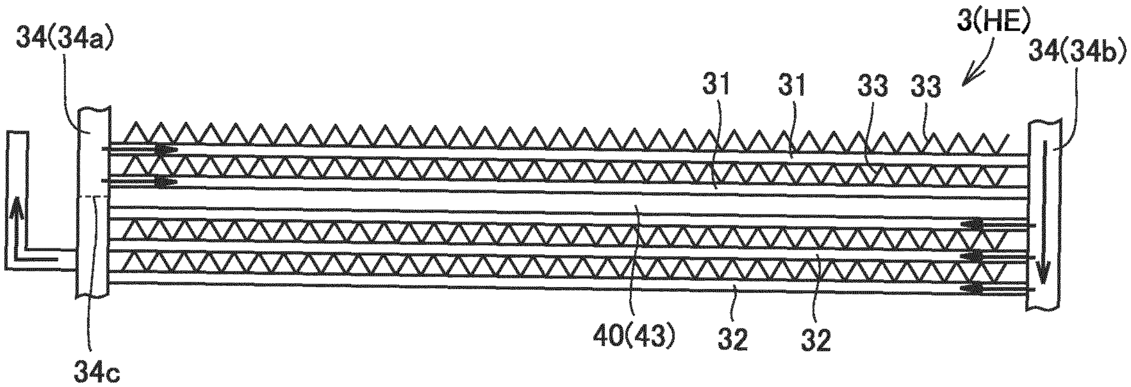


FIG.12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/025605

A. CLASSIFICATION OF SUBJECT MATTER

F25B 39/04(2006.01)i; ***F28F 9/02***(2006.01)i
FI: F28F9/02 301D; F25B39/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B39/04; F28F9/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2021
Registered utility model specifications of Japan 1996-2021
Published registered utility model applications of Japan 1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	WO 2019/043768 A1 (MITSUBISHI ELECTRIC CORP) 07 March 2019 (2019-03-07) paragraphs [0011]-[0056], fig. 1-7	1, 3-4, 6 2, 5
A	JP 2001-50685 A (SANYO ELECTRIC CO LTD) 23 February 2001 (2001-02-23) entire text, all drawings	1-6
A	JP 2018-119743 A (HITACHI JOHNSON CONTROLS AIR CONDITIONING INC) 02 August 2018 (2018-08-02) entire text, all drawings	1-6
A	JP 2014-137165 A (SHARP CORP) 28 July 2014 (2014-07-28) entire text, all drawings	1-6
A	JP 10-9713 A (DENSO CORP) 16 January 1998 (1998-01-16) entire text, all drawings	1-6
A	JP 2002-228380 A (MATSUSHITA ELECTRIC IND CO LTD) 14 August 2002 (2002-08-14) entire text, all drawings	1-6

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 September 2021	**28 September 2021**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/025605

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 41583/1993 (Laid-open No. 12782/1995) (ZEXEL CORP.) 03 March 1995 (1995-03-03), entire text, all drawings	1-6

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/025605

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2019/043768 A1	07 March 2019	GB 2578391 A paragraphs [0011]-[0056], fig. 1-7 CN 111094875 A	
JP 2001-50685 A	23 February 2001	(Family: none)	
JP 2018-119743 A	02 August 2018	US 2019/0339027 A1 WO 2018/138972 A1 CN 110168301 A	
JP 2014-137165 A	28 July 2014	WO 2014/112322 A1 CN 104903656 A	
JP 10-9713 A	16 January 1998	(Family: none)	
JP 2002-228380 A	14 August 2002	(Family: none)	
JP 7-12782 U1	03 March 1995	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2014040983 A **[0002] [0003]**